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Character association and path analysis of seed yield and its yield components in black gram (*Vigna mungo* (L.) Hepper)

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Abstract
An experiment was carried out to estimate the character Association and path analysis for thirteen quantitative characters in 60 genotypes of Black gram (*Vigna mungo* (L.) Hepper) including four standards checks during kharif 2017. Association estimates revealed that seed yield per plant showed positive and significant correlation with cluster per plant, number of pod per cluster, number of pods per plant, 100-seed weight, and biological yield per plant and harvest index at both genotypic and phenotypic levels. Correlation for seed yield per plant was divided into direct and indirect effects of different characters. Highest positive direct effect on seed yield per plant was exhibited by cluster per plant (11.48) followed harvest index (1.23). While, high indirect effect on seed yields per plant was exhibited positive and negative through other character.

Keywords: Variability, correlation, path analysis

1. Introduction
Blackgram [*Vigna mungo* (L.) Hepper] is an annual, short duration, self-pollinated, leguminous crop belong to family leguminoseae sub family Papilionaceae with a chromosome number of 2n=2x=22, it is commonly known as Urd bean. It is a cheap source of dietary protein (24 per cent), which also contains 67 per cent carbohydrates, 3-5 per cent fibre and 1.74 per cent fat. It also contributes a major portion of lysine in the vegetarian diet and fairly good source of vitamins like thiamine, niacin, riboflavin and much needed iron and phosphorus. It also has a wide range of economic value. It is well known that 50 g pulses/person /day should be consumed in addition to other sources of protein such as cereals, milk, meat and egg which is a very difficult task to achieve as the production and productivity of pulse crop including black gram is very low. To improve such important pulse crop through breeding, study on association of characters with each other and their direct and indirect effect on seed yield. Seed yield being a complex character is very difficult to improve by selecting the genotypes for yield, therefore identifying the characters which are closely related and have contributed to yield becomes highly essential. Therefore, the present study was conducted in black gram to study the genetic parameters correlation and path coefficient effects of different yield components on seed yield.

2. Material and Methods
The experiment carried with sixty genotypes including four checks *viz*., (PU31, PU1, KPU405, KPU524-65) of Blackgram were sown in three replication in a Randomized Block Design during *kharif* -2017 at the Botany field, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. Each genotype was accommodated in one row plot of 4.0 m length with a spacing of 30 cm between rows and 10 cm between plants. All the recommended package of practices of zone IVA of Rajasthan was followed to raise a healthy crop. Observations were recorded on five randomly selected plants from each treatment in each replication for all the characters except days to 50 per cent flowering and days to maturity as they were recorded on plot basis in each replication for each genotype. The representative bulk sample from each entry in each replication was used for analysis of protein content. Mean value of 5 plants were used for statistical analysis. The data was subjected to statistical analysis and estimates of correlation coefficients and direct and indirect effects of yield components on yield were calculated as method suggested by Dewey and Lu (1959) [2].

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3. Results and Discussion

The analysis of variance revealed significant difference among the genotypes for all the fourteen characters studied (Table 1). In the present study, the variation among genotypes was estimated as coefficient of variation and the phenotypic coefficient of variance (PCV) was slightly higher in magnitude than genotypic coefficient of variance (GCV) for all the characters studied indicating the interaction of genotypes with environment (Table 2). Heritability is a measure of genetic relationship between parents and progeny. In the present study, heritability estimates were medium to high for all characters. High heritability alone is not sufficient enough to exercise selection unless the information is accompanied with substantial amount of genetic advance. Thus genetic advance is another important selection parameter which is exploited along with heritability to predict the genetic advance of the trait. The estimates of heritability were moderate to high maximum characters. However, maximum heritability was found for 100-seed weight (92%) followed by number of pod per plant (90%) and pod length (88%). While, maximum genetic gain was observed for number of pod per plant (48.17%), seed yield per plant (47.06%) followed by cluster per plant (43.38%) and harvesting index (41.01%).

Table 1: Analysis of variance for different characters in blackgram

SN	Characters	Replication	Genotype	Error
		[02]	[59]	[118]
1	Days to 50 per cent flowering	3.07	15.04*	1.43
2	Days to 75 per cent maturity	1.85	24.23*	2.40
3	Plant height	2.06	23.09*	1.36
4	Number of primary branch per plant	0.01	0.15**	0.03
5	Clusters per plant	1.12	20.90**	0.89
6	Number of pods per cluster	0.17	0.60**	0.07
7	Number of pods per plant	8.08	223.13**	8.19
8	Pod length	0.14	1.06**	0.05
9	Number of seeds per pod	0.75	1.54**	0.26
10	100-Seed weight	0.27	58.41**	1.56
11	Biological yield per plant	15.56	50.87**	6.16
12	Seed yield per plant	0.65	6.16**	0.52
13	harvest index per cent	5.43	124.45**	10.98
14	Protein content per cent	0.08	2.63**	0.13

[ ] Degrees of freedom
*, ** Significant at 5% and 1% level of significance, respectively

Correlation analysis revealed seed yield per plant was positively and significantly correlated at both genotypic as well as phenotypic level with cluster per plant (rg =0.23**, rp =0.20**), number of pods per cluster (rg =0.32**, rp =0.23**), number of pod per plant (rg =0.37**, rp =0.30**), 100-seed weight (rg = 0.38**, rp = 0.33**), biological yield per plant (rg = 0.52**,rp = 0.53**), harvest index (rg =0.66**, rp =0.63**) and negative significantly correlated with protein content(rp = -0.42**, rp = -0.36**).(Table 3). The similar finding were also reported by Mathivathana *et al.* (2015) [6]. This suggests selecting for the characters with high positive correlation would improve the seed yield in Black gram. Path analysis revealed that number of cluster per plant, number of pods per cluster, pods per plant, 100 seed Weight, biological yield per plant and harvest index exhibited positive significant association with seed yield per plant showed true relationship by establishing positive association and direct effect on seed yield both at genotypic and phenotypic levels. (Table 4). Considering the nature and magnitude of character association and their direct and indirect effects, it can be inferred that improvement of seed yield is possible through simultaneous manifestation of cluster per plant, number of pods per cluster, number of pods per plant, 100 seed Weight, biological yield per plant and harvest index.

4. Conclusion

Magnitude of phenotypic coefficients of variation in selected blackgram germplasm was higher than genotypic coefficients of variation, indicating that environmental factors are influencing studied characters. High genetic advance and high heritability was recorded for number of pods per plant and harvest index hence selections based on the traits could improve productivity in blackgram directly.

Table 2: Variability parameters for various characters in blackgram genotypes

S. No	Character	GCV%	PCV%	H²%	GA	GG%
1	Days to 50 per cent flowering	5.15	5.90	76.21%	3.82	9.24
2	Days to 75 per cent maturity	3.53	4.07	75%	4.82	6.31
3	Plant height	12.48	13.61	84%	5.09	23.58
4	Number of Primary branch per Plant	6.55	8.45	60%	0.32	10.45
5	Clusters per plant	22.42	23.86	88%	5.00	43.38
6	Number of Pods per cluster	13.90	16.59	70%	0.72	24.01
7	Number of pods per plant	24.68	26.06	90%	16.52	48.17
8	Pod length	14.46	15.42	88%	1.12	27.95
9	Number of seeds per pod	9.51	12.09	62%	1.06	15.40
10	100- Seed weight	17.91	18.63	92%	8.62	35.45
11	Biological yield per plant	19.43	23.10	71%	6.69	33.66
12	Seed yield per plant	25.82	29.18	78%	2.50	47.06
13	harvest Index%	22.61	25.69	78%	11.15	41.01
14	Protein content%	4.08	4.37	87%	1.76	7.83

Table 3: Genotypic (above diagonal) and Phenotypic (below diagonal) correlation coefficients among different characters in Blackgram genotypes

Vv s.no.	Character	Days to 50% Flowering	Days to 75% Maturity	Plant Height	Number of Primary branch per Plant	Clusters per Plant	No of Pods per Cluster	No of Pods per Plant	Pod Length	No of Seeds per Pod	100 Seed Weight	Biological Yield per Plant	harvest Index %	Protein Content %	Seed Yield per Plant
1	Days to 50% Flowering		0.288**	-0.013	0.026	0.012	0.074	0.076	0.213*	-0.041	-0.023	-0.049	0.240*	-0.120	0.180
2	Days to75% maturity	0.197**		0.086	0.053	-0.019	0.309**	0.135	0.309**	-0.251**	-0.028	-0.251*	0.142	0.121	-0.066
3	Plant height (cm)	-0.015	0.040		-0.027	0.772**	0.173	0.782**	0.421**	0.058	0.386**	0.412**	-0.172	0.166	0.146
4	Number of primary branch per plant	0.040	0.003	-0.022		0.067	0.007	0.069	0.078	-0.277*	0.015	0.197	0.093	0.247*	0.201
5	Number of cluster per plant	-0.009	-1.017	0.663**	0.021		-0.074*	0.902**	0.221*	0.093	0.406*	0.500**	-0.149	0.089	0.237**
6	Number pod per cluster	0.057	0.219**	0.123	0.026	-0.163*		0.352**	0.386**	-0.011	0.218*	0.036	0.348**	-0.136	0.329**
7	Number pod per plant	0.049	0.108	0.677**	0.032	0.805**	0.376**		0.376**	0.082	0.466**	0.411**	0.074	-0.033	0.378**
8	Pod length	0.184**	0.248**	0.351**	0.043	0.189*	0.328**	0.333**		-0.176	0.027	0.001	0.066	0.210*	0.030
9	Number of seed per pod	-0.070	-0.201**	0.055	-0.187*	0.073	-0.024	0.056	-0.105		0.326**	0.059	0.053	-0.018	0.077
10	100-seed weight	-0.012	-0.023	0.339**	0.022	0.365**	0.165*	0.428**	0.030	0.241**		0.215*	0.302**	-0.067	0.388**

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
11	Biological yield per plant (g)	-0.085	-0.170*	0.324**	0.099	0.425**	0.017	0.343**	-0.014	0.021	0.178*		-0.262**	0.161	0.523**
12	Harvest index (%)	0.186**	0.094	-0.146	0.091	-0.140	0.253**	0.039	0.052	-0.003	0.252**	-0.262**		-0.569**	0.669**
13	Protein content (%)	-0.100	0.113	0.127	0.206**	0.068	-0.116	-0.041	0.165*	0.005	-0.070	0.161	-0.502**		-0.422**
14	Seed yield per plant	0.103	-0.060	0.119	0.140	0.209**	0.230**	0.309**	0.007	0.050	0.330**	0.523**	0.635**	-0.368**	

*, ** Significant at 5% and 1% level of significance, respectively

Table 4: Direct (diagonal) and indirect effects of different correlated characters towards seed yield per plant

Character	Days to 50% Flowering	Days to 75% Maturity	Plant Height	No of Pb/ Plant	Clusters/ Plant	No of Pods/ Cluster	No of Pods/ Plant	Pod Length	No of Seeds/ Pod	100 Seed Weight	Biological Yield/ Plant	harvest Index%	Protein Content%	Rg
Days to 50% Flowering	0.1857	0.053	-0.002	0.004	0.002	0.013	0.014	0.039	-0.007	-0.004	-0.0091	0.0445	-0.022	0.18
Days to 75% Maturity	0.0114	0.039	0.0034	0.0021	-0.0008	0.0123	0.0054	0.0123	-0.0100	-0.001	-0.010	0.005	0.0048	0.06
Plant Height	-0.0012	0.008	0.0952	-0.0026	0.0735	0.0165	0.0745	0.0401	0.0056	0.0368	0.0393	-0.0164	0.0158	0.14
No of Pb/ Plant	0.0080	0.015	-0.0081	0.3019	0.0201	0.0023	0.0207	0.0237	-0.0835	0.0044	0.0596	0.0280	0.0746	0.20
Clusters/ Plant	0.1423	-0.222	8.8377	0.7618	11.4503	-0.851	10.324	2.5298	1.0703	4.6436	5.7278	-1.7104	1.023	0.23**
No of Pods/ Cluster	0.3556	1.490	0.8360	0.0362	-0.3591	4.828	1.701	1.861	-0.051	1.053	0.1737	1.6813	-0.654	0.32**
No of Pods/ Plant	-0.8838	-1.573	-9.0950	-0.798	-10.4858	-4.097	-11.629	-4.372	-0.956	-5.423	-4.7829	-0.8568	0.3869	0.37**
Pod Length	-0.0084	-0.012	-0.0167	-0.003	-0.0088	-0.015	-0.0149	-0.039	0.0070	-0.001	-0.0001	-0.0026	-0.008	0.03
No of Seeds/ Pod	-0.0061	-0.037	0.0087	-0.041	0.0139	-0.0016	0.0122	-0.026	0.1485	0.0484	0.0087	0.0078	-0.002	0.07
100 Seed Weight	0.0076	0.009	-0.1288	-0.004	-0.1351	-0.0727	-0.1554	-0.009	-0.108	-0.333	-0.0717	-0.1007	0.0223	0.38**
Biological Yield/ Plant	0.0100	0.051	-0.0838	-0.040	-0.1017	-0.0073	-0.0836	-0.0003	-0.0119	-0.043	-0.2033	0.0533	-0.032	0.52**
harvest Index%	0.296	0.175	-0.212	0.1147	-0.1845	0.4300	0.0910	0.0809	0.0652	0.373	-0.3237	1.235	-0.702	0.66**
Protein Content%	0.0632	-0.0636	-0.0876	-0.1303	-0.0471	0.0715	0.0175	-0.1105	0.0096	0.0353	-0.0848	0.2999	-0.5270	-0.42**

*, ** Represent significant at 5% and 1% level of significant respectively
Diagonal bold values represent direct contribution of traits on seed yield per plant r represent the genotypic correlation coefficient for seed yield per plant, Residual effect = 0.402

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